Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Molecular Sciences

Mapping technological development in fisheries 1800-2020: a document analysis

Erika Haug

Master's Thesis, 30 credits
Sustainable Food Systems – Master's Program
Degree Project/SLU, Department of Food Science
Molecular Sciences, 2021:50
Uppsala, 2020

Mapping technological development in fisheries 1800-2020: a document analysis.

Erika Haug

Supervisors: Jonas Hentati Sundberg, Swedish University of Agricultural Sciences
Department of Aquatic Sciences

Ruth Thurstan, University of Exeter
Department of Biosciences

Examiner Penilla Tidåker

Credits:	30 hp
Level:	A2E
Course title:	Master Thesis in Food Science
Course code:	EX0875
Programme:	Master's Programme Sustainable Food Systems
Course coordinating dept:	Department of Molecular Sciences

Place of publication:	Uppsala
Year of publication:	2020
Title of series:	Molecular Sciences
Part number:	2021:50

Key words: Industrialization, Fisheries, Timeline, Fishing, Food Systems

Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Molecular Sciences

Abstract

Fisheries are an important source of food for many people around the world. As food became industrialized, fisheries became industrialized too. There are many research projects trying to understand the development of certain technologies and what it means for fisheries and management of fisheries. By relating the impact of the different technologies on the sustainability of fisheries we can attempt to mitigate or at least be aware of the possible impact of these technologies. Each new technology increases the ability of fish to be caught. Understanding where and when new introductions of technology occurs can help understand the impacts of fishing in those times and areas. This study aims to qualify the rate of development over time of a list of 208 different technologies from 8 different categories of technologies within fisheries: catch handling and storage, fish finding, fishing gear and operation, gear handling and operation, hulls and propulsion, navigation and communication, vessel types, and working conditions and safety. The goal of this work is to provide more quantitative research to help promote successful and healthy management of fisheries by examining and further understanding the impact of the rate of development of new technologies relating to catch numbers in fisheries. Using Google Books and sourcing from multiple publications such as government publications, magazine/journals, books, FAO, corporate reports, dictionary/encyclopedias, and newspapers, the first mention of each technology in published works was documented. Publications were examined from 1800 to 2020. This data was then used to understand the timeline and different rates of development. Development in these technologies has not been steady. The most important results of this research were spikes of development during 1880, and from 1947-1960**.** These correlate with the introduction of industrial fishing and the industrialization of food post WWII.

Terms

Aquaculture: Growing seaweed, fin fish, mollusc and other sea creatures in controlled environments

Baseline: an initial observation such as initial populations that can be used to compare and track historically in fisheries (Merriam-Webster, 2021).

Capture Fisheries: wild fisheries exploited by catching (or capturing) fishing stocks

Catch: The total weight of fish harvested during a specific time period

Catch Efficiency: The catch yields related to the amount of energy put in

Catch per unit effort: total catch divided by total engine power and the number of fishing days in a year (Kilowatt days) (Anticamara et al., 2011)

Demersal: bottom-dwelling species of fish (Merriam-Webster, 2021)

Effort: work done to achieve an end, such as work done to catch a fish (Merriam-Webster, 2021).

Fishes: multiple species of fish

Fisheries: “the occupation, industry, or season for taking fish or other sea animals (such as sponges, shrimp or seals)” (Merriam-Webster, 2021).

Stocks: populations of fishes

Technology: “[T]he use of science in industry, engineering, etc., to invent useful things or to solve problems” (Merriam-Webster, 2021)

Technology Creep: the mostly continuous introduction of new technologies (Eigaard et al., 2014)

Table of Contents

List of Figures

1 Introduction

1.1 Background

1.1.1 Fisheries as part of the food system

Fisheries are an important part of the global food system. They provide direct income to 59.5 million people world-wide (FAO, 2020). If fisheries can be sustained by carefully managed practices and regulations they have the potential to mitigate micronutrient deficiencies which cause the death of about one million people per year (Hicks, et al., 2019). The World Health Organization (WHO) has acknowledged that the rate of food insecurity in the world is rising (FAO et al., 2018). As this rate rises, it can lead to further challenges and inequities in education as well as mental health. While not the only source of food, sustaining fisheries can help some world populations have a food source with a high nutritional value available. Fisheries being managed sustainably and remaining a resource can be a part of the solution to decreasing food insecurity.

Not only do fisheries provide valuable nutritional and economic resources, but they are of great cultural importance to many people around the world. Protecting this resource from overfishing and illegal fishing, is one of the greatest challenges faced by fisheries managers today (FAO, 2020). Knowing what fisheries looked like historically, as well as continued monitoring, provides valuable information to guide policy and practices to help sustain fisheries around the world (Suuronen, et al., 2012).

Historical context for fisheries could give insight into a baseline population density, information about life history of fishes, and help understand historical ranges. This information is key to understanding the changes in fisheries and how they have been impacted by developments in technology. A better understanding of the past can lead to better management practices in the present to provide for a better future for fisheries. Currently, using catch data is a common way to understand changes in and the health of fisheries. Adding the historical context of added efficiencies of

fishing can give insights into population changes of fishes based on the interaction of catch data and technology development.

1.1.2 Technological change in fisheries

While catches have remained relatively consistent, more effort and technology have increased efficiencies in fisheries. More areas have been opened up to fishing and more boats are on the water participating in the catch (Anticamara et al., 2011). This leads to the conclusion that stocks are declining. When stocks are declining it is important to know when a certain species or population is overexploited. A baseline of stock densities is desirable for this research and to measure what level of exploitation each population of species suffers.

Fishing became industrialized with the introduction of the steam-powered trawler in the 1880s in the waters surrounding England (Gabriel et al., 2005). After that initial introduction, new technologies were continually added in the pursuit of catching more fish. This phenomenon is called technological creep, and refers to the mostly continuous introduction of new technologies (Eigaard et al., 2014). Not only is increasing the quantity of fish caught a goal, but there is also the goal of increasing the efficiency of catching fish. Increased efficiency of fishing would ideally lead to higher profits.

It is important to correctly manage fisheries because they contribute to many cultures, economies, employment, and are an important food supply for a large part of the world. It is estimated that 50 billion USD are lost annually for fisheries that do not improve catch amounts (Anticamara et al., 2011).

The pressure on fisheries is not wholly reflective of the effort and success that is put in. The pressures are any forces that have a negative impact on the fisheries such as changing weather patterns. There are many other factors to be accounted for. To manage fisheries efficiently there must be an understanding of the effort and success through new technological developments, changes in costs and effort,

improvement in navigational aids, and improvements in safety (Eigaard et al., 2014).

New technologies are introduced to attempt to increase financial gains. The new technologies fall into one of four basic categories: increasing catch numbers, increasing profits, increasing the value of the catch, reducing the costs of fishing, and increasing the comfort and safety of fishing at sea (Eigaard et al., 2014).

1.1.3 Measuring technological change

There have been many attempts to understand the historical effect of technology in fisheries, but lacking documentation in the early years and decades of fisheries has posed a problem. One way to measure impacts on fisheries is to look at the inputs and outputs of fisheries as a whole. Looking at the global catch can be a method of measuring the size of fisheries and their change over time. As we know, technology creep adds more efficiency to the catch initially, therefor we can look at global numbers for catch. Global fisheries catch peaked at 130 million tons in 1996 and has since declined. While small-scale fisheries are not included or are underreported in these findings, industrial catches are certainly shown to be declining and at a steeper rate than in the previous century (Pauly & Zeller, 2016). Pauly and Zeller (2016) was able to recreate catch by country based on FAO (Food and Agricultural Organization of the UN) reports. The study began in 1950 because that is when FAO started to publish reports on reported catches. While starting with 1950 does add a large time scale to the data, it is still much later than the start date of industrial fishing in the 1880s. The 1950 start date does however give a chance for more available data. It is important to note that the study does recognize that underreporting is a serious problem with the FAO and their method of data collection (Pauly & Zeller, 2016).

Outputs of fisheries can be tracked by extrapolating CO_2 emissions. Looking at the CO_2 emissions from global fishing can also provide insight into the increased availability of technology and increased catch efficiency. Greer et al. (2019) calculated an 408% increase in emissions from industrial fisheries and a 600%

increase in small-scale fisheries from between 1950 and 2016. While these numbers don't provide much insight into catch efficiency, the information they provide about technology increase can be compared to catch data for a clearer picture of what these increases mean for the efficiency of fisheries. While focused on fuel consumption, this research does admit that there is a dearth of available data that directly relates to fuel consumption. They solved this problem by looking at multiple factors. By looking at each country they measured the number of boats on the water, what sector each vessel applied to, the gear onboard, the length of the vessel, and the motorization of that vessel. This provided extrapolated data on the fuel consumption of each fleet that could be compared over time and to other countries around the world.

Another way to look at fisheries as a whole is to look at how global waters used in fisheries have grown over time. The global area now open to fisheries has been expanded due to introduced technology. This technology has increased the ocean area open to fishing by over 50% making it equivalent to an area four times what is in current use by agriculture. While the specific areas are subject to cultural and political events, the increase in area tells the same story of fisheries using technology to expand their capacities, and to search for more fish in more places (Kroodsma, et al., 2018).

As the area available to fishing increases, so too does the number of fishing vessels on the water tell of increased technology and efficiency. Between 1950 and 2015 the global fishing fleet doubled. When comparing the Catch Per Unit Effort (CPUE), which can be described as the catch divided by effort, the 2015 CPUE is about 1/5 of the values noted in the 1950s. The increase in fleet and decrease in effort for increased efficiency is a consistent correlation since 1950 (Rousseau et al., 2019). To come to these conclusions the fishing data from 152 sovereign states and islands were collected. The national databases were used with a literature review to extrapolate fishing fleet data per region, and around the globe. By categorizing vessels in the fleet and the days at sea, total fleet power could be discovered.

Measuring the efficiency of fishing can be an extremely helpful way to get insight into how fisheries are changing. The previously mentioned limitations of the included studies can be addressed by looking at technology instead of fisheries data. While fisheries data might have limitations, looking at technology development can answer some questions that the limitations of fisheries data might leave out about the timeline.

Measuring the increase of yield and decrease in energy per fish in fisheries can be important for a variety of reasons. It can lead to results that can be important for management such as a rapid decline in demersal stocks. This information can be used to help governments better manage fisheries since some fisheries are managed in an effort-based manor and governments will use that information to set regulations. It can also lead to conclusions such as: 78.5% of stocks with scientific advice on management are fished in a manner that is unsustainable (Damalas, Maravelias, & Kavadas, 2014). All of these insights lead to better management and protection of fishes and fisheries.

The catch efficiency can be measured in various ways. Anticamara et al. (2010) measured the global fishing effort. The result stated that starting in the 1950s there was a constant effort until the 1970s. After the 1970s there was a constant increase in effort from that time to the present. They found the global fishing effort to exceed what they considered optimum by a factor of three to four. They saw rising efforts while stocks declined, prices that stabilized or declined, overexploitation of stocks, and rising subsidies to make up the difference. This study used data from the FAO, Europa fishing fleet data, peer-reviewed publications, and other publications to come up with their results. They used multiple sources of data to cross-reference data and increase accuracy. However, both of these sources had their limitations, and Europa only has data for the European Union. The publications used were focused between 2000 and 2010. This allowed for additional verification of data results and provided data that was less patchy from before 2000. This does limit the

scope of the study to between 2000 and 2010 and can miss data on when fisheries were going through some of the biggest changes.

Another method for measuring efficiency with addition of new technologies is by comparing catches between boats that have certain technologies and those that don't. This comparison shows that a GPS can increase yields by 4%, a plotter can increase yields by 7%, and each additional year with these technologies can increase yields by 2-3% (Robins, Wang, & Die, 1998). The data for this research was collected using logbooks and landings returns. This data then compares between vessels that have certain technologies and those that do not. It also collects data over time with each technology. This certainly seems like a good way to judge the improved efficiency (catch per effort) of certain technologies to increase catch per fishing hour on the landings of each trawler. However, that would consider all else being equal. It isn't directly addressed if a trawler with GPS might have other technologies that might impact their landings and effort.

Comparing catches to power used can also be beneficial. Understanding that fishing power has increased 50-100 times in the past 120 years is important on its own, but comparing to catch rates can expose that catch rates lag behind this incredible increase. This points to the conclusion that fisheries are being overexploited and can lead to better management practices in the future (Engelhard, n.d.).

While each of these methods has benefits and can expose more about the nature of technology creep in fisheries, there are also some serious limitations to consider. Looking at the global fishing effort, global catches, emissions, fishing area, number of vessels, and comparing certain technologies are all key indicators of trends. They can provide a piece of the puzzle to be put together with others and draw conclusions. They are however all very specific in measurements or technology.

Quantifying a baseline to fisheries is very important and connecting that to a baseline of technology can give a deeper understanding of changes over time (Swartz & Ishimura, 2014). Going back to the beginning of industrial fisheries, a

technological baseline can be an important factor in understanding the development of fisheries. It can put context around the information already available such as global catch, global fishing fleet, and global emissions. Adding the baseline to current research will expand the understanding of the history of fish stocks, including impacts of fishing, and facilitate current understandings of each stock. It can also help inform management to plan for the future. Having an historical baseline gives a greater indication of what stocks should look like and what restoration means.

While an historical baseline is important, it is also important to understand the rate of change of the introduction of new technologies. Starting from the beginning of industrial fisheries to the present time there have been many new technologies introduced, but not all at the same time. They also do not come at a constant rate. Introduction of new technologies drives economic growth and can happen at various rates (Farmer & Lafond, 2016). Understanding not only do technologies change, but that they change at various rates can give greater insight into fisheries development.

Understanding the development of fisheries is very complex and there are many factors to be taken into account. Each new invention, technological adaptation, or technological dependence has an impact on the fishing industry. Understanding the variety of new technologies and the sequence, or timeline, of introductions can give a broader, and more precise, understanding of what new technology introductions mean for the fisheries industry.

1.2 Aim and Approach

The objective of this study is to create a quantitative look at the rate of the increase in technologies introduced into fisheries as they became industrialized. The aim is to better understand the development of technologies in fisheries over time. The rate of development of technologies can be compared to multiple variables to understand the changes in fisheries.

Collecting this data could take many forms. To approach this there needs to be raw data that can be collected and categorized to assign quantitative numbers to the development of technology in fisheries over time. Once assigned, this data can be used to look at development over time and to better understand the path that industrialization took on fisheries.

.

2 Materials and Methods

Google Books is a large collection of scanned and uploaded books dating from 1800 to present. It has been made possible by libraries digitizing and uploading their collections. The documents are then put through an optical character recognition software so the program can search the books for terms. Searching through Google Books and collecting data has been used for recording cultural trends since 2011 (Michel, et al., 2011).

Recently Google Books has been used alone and in conjunction with other searches to not only look at cultural trends, but also the development of language (Sun & Baayen, 2021). An extensive digital library of over 200 years of published works is also extremely valuable when looking at technology development in general. But it doesn't stop there, this resource has been used to gain further insights into collective memory, the phenomenon of the pursuit of fame, and even epidemiology (Du et al., 2021). More specifically, it has been, and is, being used to understand the perception of the COVID-19 pandemic (Hu et al., 2020).

To start working with Google Books, a list of terms must be available for searching and data collection. The word list (Appendix 1) was provided to me by Jonas Hentati Sundberg from an expert workshop he attended on fisheries technology. The list covered technologies known to be in use in the recent and more distant past, and was collated via consultations with fisheries scientists and the fishing technology literature to create a broad list of past and present technologies known to be in use in fishing vessels around the world. They broke down the terms into various categories such as: catch handling and storage, fish finding, fishing gear and operation, gear handling and operation, hulls and propulsion, navigation and communication, vessel types, and working conditions and safety.

Dates of first recorded use of each of the terms in fisheries was gathered using Google Books. The term was placed in quotations followed by the word 'fish' (e.g. "power steering", fish). Google Books will keep the term in quotations in its

original form. The word outside of quotations will search based on the root word. The addition of the word ‘fish’ will come up with the terms “fishing”, “fishery”, and “fisheries” in addition to “fish”.

This is a slight departure from usual search terms and tools. Adding the expected “+” to indicate both the terms should be included only searches for the mention of either of the terms. This produces a list that has vastly more results, but does not indicate the overlap. Leaving the “+” out indicates the desired search will result in documents where both terms are present. Also, typically to search for words with alternate endings “fish*” would be used. This does not produce the desired results and therefor just adding the word ‘fish’, not in quotations, has the desired effect of pulling up sources that contain a word with the root ‘fish’ in it. The quotations are reserved for words or phrases that should be searched just as they appear in the quotations. This is useful especially while searching terms that have more than one word and need to stay in order to be applicable, for example “Variable Range Marker”. Turning up search results that hit on some type of marker at a variable range would not give the correct context of the words and therefor would not be useful in finding mentions of the technology.

When the search bar has been filled, the search parameters are set. For this research “search English pages,” “preview available,” “any document,” and “sort by date” were selected. The dates were changed while searching for the term in the appropriate context. First “19th century” was selected. If there were no approved entries, then “20th century” followed by “21st century” were selected. The lists of

entries were read from the bottom up to read from earliest to most recent published work.

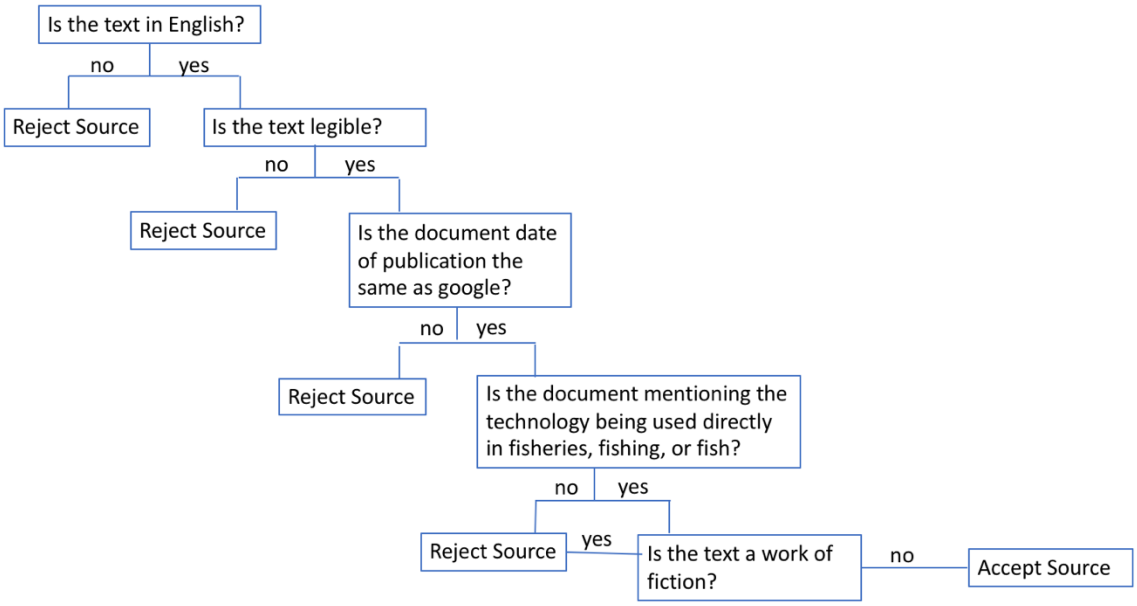

Figure 1. Source key used to determine whether to accept or reject a source from the Google Books search.

Figure 1 was used as a key to determine if the source would be accepted or the next available source (by year) was to be considered. If multiple works were available for a year the list was still worked on from the end of the list up. In order to be accepted the document must be; in English, legible, the publishing information is available for preview in the document, the dates of publication on the document and on Google Books must match, and the document is mentioning the technological term being used directly in fisheries, fishing, or fish. Works of fiction were also rejected.

Once a document was accepted, more information was taken from the source. The date of publication was taken, but also location of publication, location of the use of the technology if it was available, and the type of publication. The categories for

type of publication were Book, Government Publication, Dictionary/Encyclopedia, Newspaper, Magazine/Journal, FAO, and Corporate Report.

3 Results

When all the data is collected it can be compared and used to build a timeline such as Figure 2. This timeline shows cumulative publications by year and has been divided to show categories. It shows that categories such as vessel types and fish finding increase relatively later. Those categories have fewer terms, while categories such as fishing gear and operation, catch handling and storage, navigation and communication, hulls and propulsion, and gear and handling operation have more terms to them. This graph also shows different rates of increase during certain time periods. For example, there is an increased rate around 1880 and 1960.

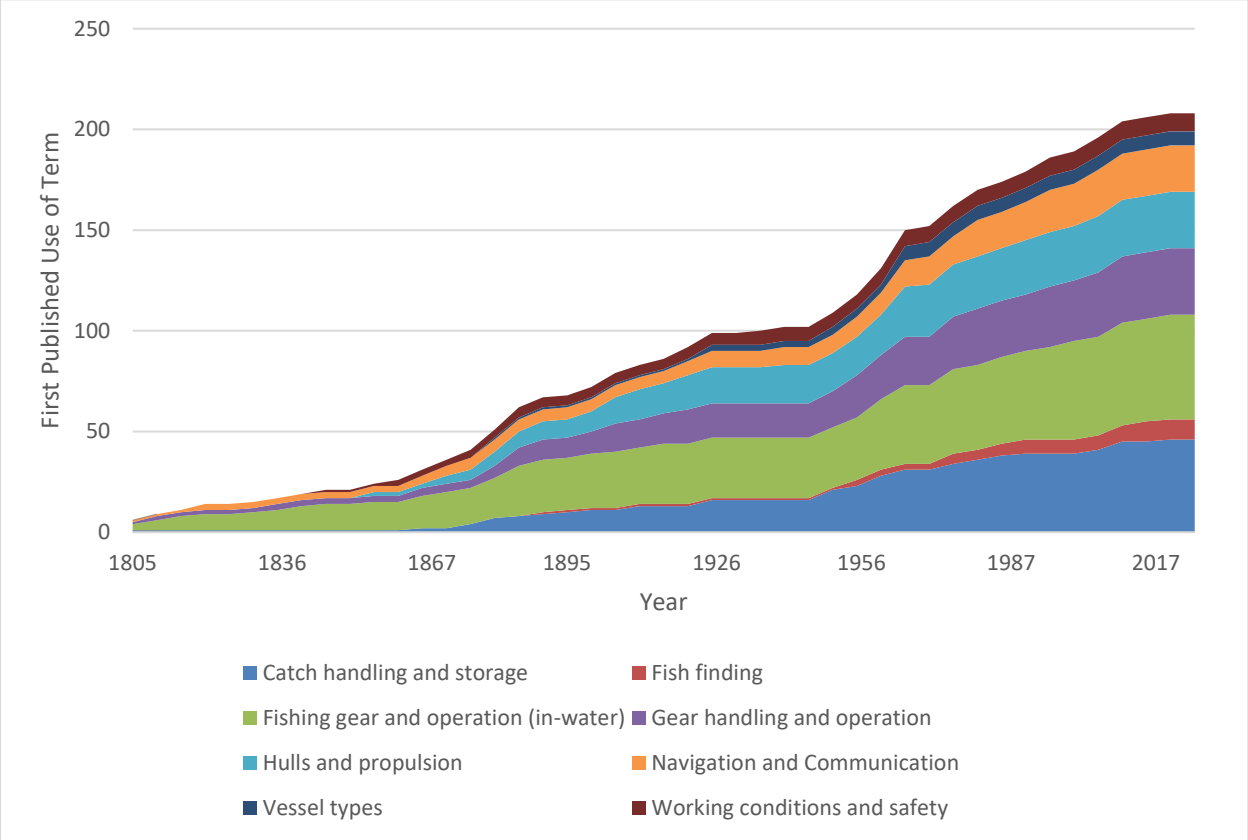

Figure 2. Cumulative introduction of new technologies by year in the fishing industry from 1800-2020.

Figure 3 has a more direct view of the changes of technologies from year to year. It shows times of fewer publications followed by peaks of more new technologies mentioned in published works. While 1820, 1845, 1925, and 1940 all have zero publications for each year, there is a spike at 1880 with 11 publications and 1960 with 19 publications.

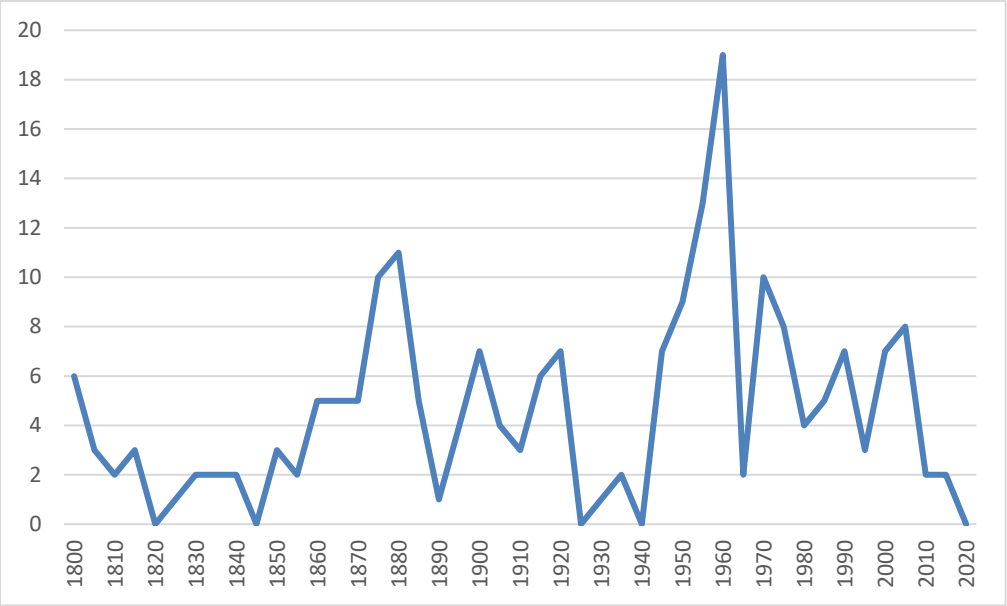

Figure 3. Number of new technologies by year in the fishing industry from 1800-2020.

Figure 4 gives more insight into each of the peaks and troughs from Figure 3. Figure 4 also allows for breaking down this same information by category. This proves that the 1880 peak is primarily in fishing gear and operation and the peak around 1960 comes from catch handling and storage, and hulls and propulsions. Different categories such as working conditions and fish finding technologies are clearly happening later in the timeline than categories such as fish gear and operation, gear handling and operation, and hulls and propulsion.

In 1880 some examples of new technologies are: refrigeration first used in fisheries, manila rope, and the purse seine. In the peak from 1947-1960 the introduction of the mothership, peeling machines, battering machines, breading lines, fileting

machines, sorting belts, ultrasonic transducers, LORAN (Long Range Navigation), radar, and ASDIC (Sonar).

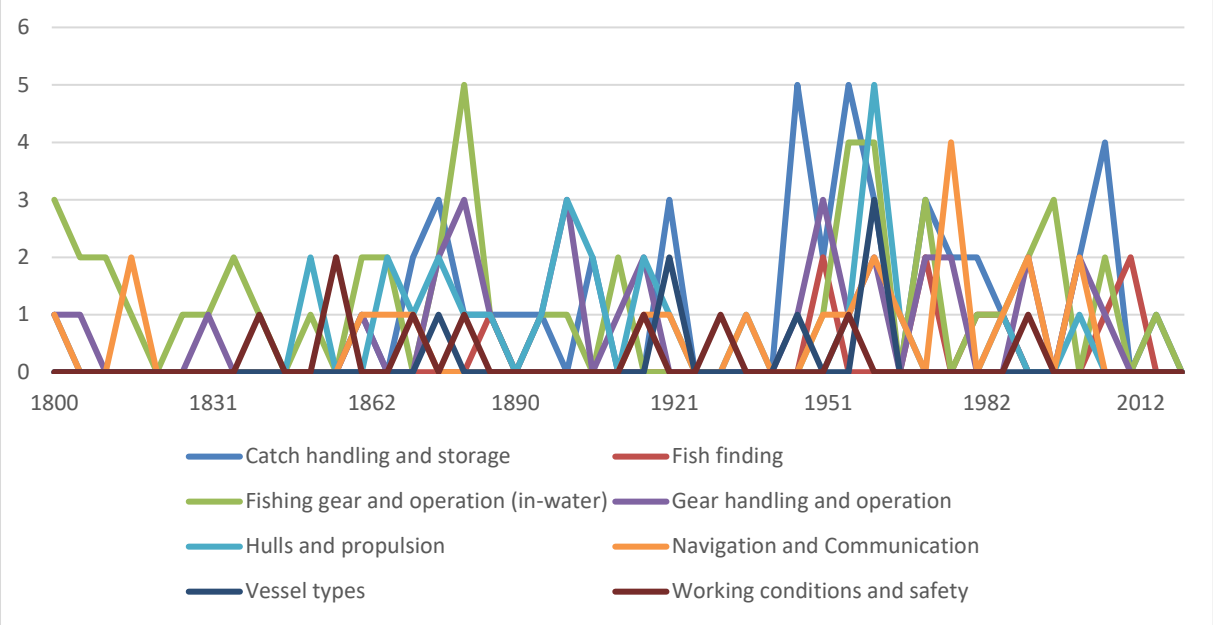

Figure 4. New technologies introduced by year in the fishing industry from 1800-2020.

Figure 5 breaks down the information by the source type as well as the category. The most common source was government publications followed by magazine/journal and books. The categories with the most terms found is fishing gear and operation followed by catch handling and storage, and gear handling and operation. The categories can give insight into which areas are growing.

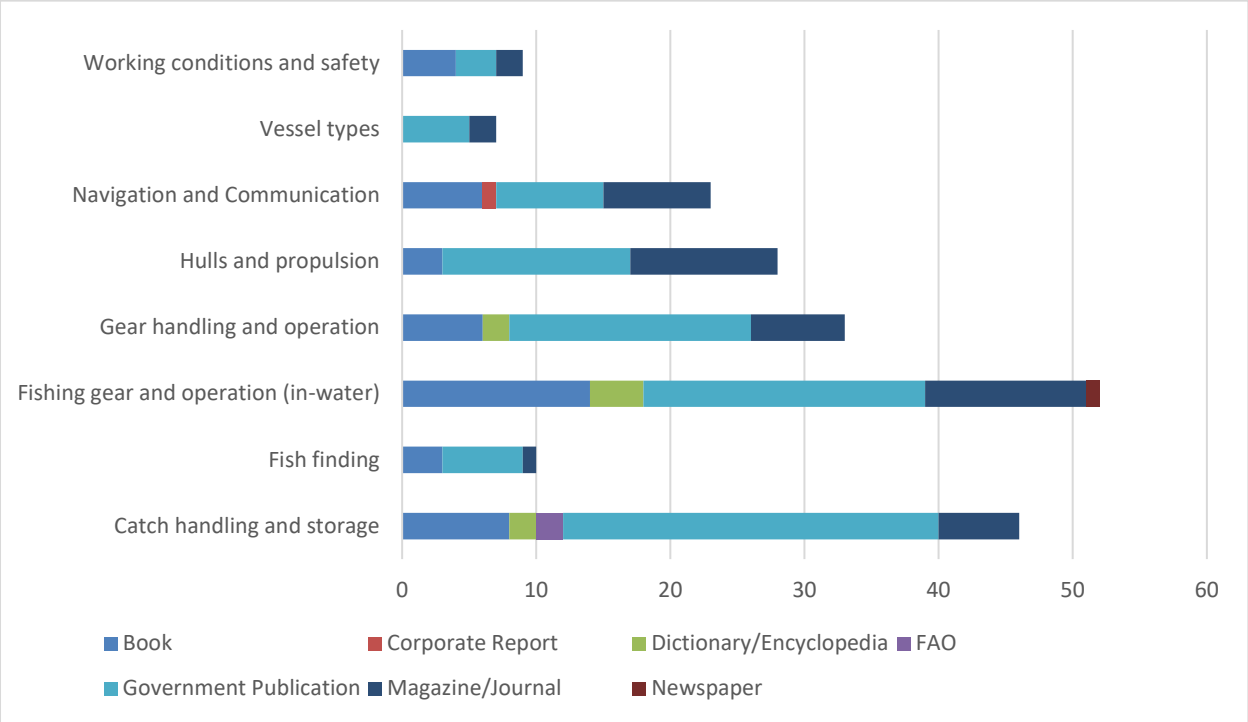

Figure 5. New technologies by category and source type introduced to the fishing industry from 1800-2020.

4 Discussion

Technology has been developing around the world and this also includes the food industry. Fisheries are included in this development of food sourcing and production. Knowing the rate of advancement of technology is important for many reasons, and new technology can also be an important tool to help scientists gain a better understanding of the state of fisheries and influence their recommendations on management of fisheries to protect this natural resource.

Using Google Books, the first published use of a technology can be gathered and compared. This ensures that the technology is used widely enough in the industry to be published in that context. While it allows for looking at a large list of words, there are some limitations from using this database.

The only works available are publications that have been scanned and uploaded by libraries and the Google Books project. While I have used a wide date range (1800-2020), there will be some expected variance between older and newer sources such as legibility and spelling. The wide date range provides a view into development through the whole of industrial fishing, instead of the more commonly seen view starting in the middle of the 20th century. There was also a limit placed on sources in that there must be a "preview available." This made it possible to check the context of the word use, but also filtered out sources that could have been an earlier mention. However, the validity of the sources was the most important factor, and limitations were considered and weighed against valid sources and data.

4.1 Analysis

The data was put into a spreadsheet and used to make a variety of illustrations that show the complex nature of the development of technologies in fisheries. Figure 2 shows an overview of the development of technology by mapping on the timeline the first published mention of the technology used in fisheries. The illustration allows for some interesting insights.

The beginning of the graph shows a slow development, as is to be expected. There are sharper increases during the times around 1880, and between 1947-1960. This is corroborated by Figure 3 which shows spikes of publications during those same time periods. The spikes can be further broken down by looking at Figure 4 which shows what category of terms is responsible.

The year 1880 is widely recognized as the beginning of industrialized fishing with the introduction of steam trawlers in the waters around England (Gabriel et al., 2005). It is not surprising that there was also an increase in other technologies at that time due to opportunities that the steam trawler provided. The 1880 spike appears to be due to a rapid development in fishing gear and operation. There is also an additional, lesser, spike in gear handling and operation. This can attribute the aforementioned 1880 spike to both increased technology in the way that fish were caught, and the gear that went into fishing. Such materials as the manila rope and purse seine were first documented in text at this time. Both allowed for more efficient capture of a large number of fish (Wilcox, 2012).

An increase in the rate of technology development in 1880 also correlates to the industrialization of food and food movements across land. Peripheral developments such as railroads and processing technologies such as refrigeration and canning allowed for increases in food production and transportation across the industry. The first published account of refrigeration being used for fish storage is in 1880. This was an invention that shaped food systems as a whole and also had a large impact on an industry of a fast-spoiling food such as freshly caught fish (Wilcox, 2012).

The 1947-1960 spike also can be related to developments in technology across the food industry and in food science. World War II had an incredible impact on food production and processing (Wilcox, 2012). In the fishing industry we can see from Figure 4 that the largest changes were happening in catch handling and storage, hulls and propulsion, fishing gear and operation, gear handling and operation, and vessel types. The industry was booming, and advancements were made in many areas of fisheries. Other improvements and government subsidies in general food

development, handing, and shipping vastly increased development during these times (Geroski & Vlassopoulos, 1991).

In the second peak, the technological introductions start in 1947 with the introduction of the mothership into the fishing industry. This is a large vessel that acts as a support for many smaller vessels. As the smaller vessels fish, the mothership receives the fish and processes them so that larger amounts can be sent back to port and smaller vessels can continually fish (Paterson, Grauf, & Smith, 1997).

In the ten years that followed, many new processing technologies were introduced. Filleting machines would cut the fish, sorting belts would divide fish based on size, peeling machines would peel shrimp, and breading lines and battering machines create the end product and ensured a continual supply of processed fish products to a growing population (Teitelbaum, 2020). As families grew and demand for processed and frozen fish products grew, the developments in the areas of catch handling and storage grew at an increasingly steep rate.

Also, at this same time, technologies that were used in war were being transitioned to purposes in a post-WWII society. After the end of WWII in 1945 many wartime technologies were transitioned to other uses, and in food production in particular (Shiga, 2013). Ultrasonic transducers and ASDIC (an early sonar used in the detection of submarines) were both technologies that were applied to fish finding in an attempt to better pinpoint the location of large numbers of fish with the eventual goal of catching and bringing those fish to market. LORAN (Long Range Navigation) and radar were also technologies utilized in the war, but where now used as navigation and communication tools for vessels at sea.

Each introduction of technology played an important role in the development of fisheries. They were not introduced at a steady rate, but instead there were booms that provided a larger group of introductions of technologies. Each of these spikes are apparent for different reasons but help illustrate the point that while different

rates of development are seen, there are also different rates in different categories of technologies at different times.

While government played a role in the development of fisheries, it also is the main source for understanding and recording this development, as shown in Figure 5. Government publications were my main source and were the most helpful in noting the use of technologies in fisheries. Additionally, trade published works such as magazines and journals were also very important. They provided firsthand accounts as well as advertisements for important new technologies. Books were also important and included many travel accounts and textbooks.
While this research answers important questions about the rate of development over time, it leaves some questions yet to be explored.

4.2 Use in Management

Using this data to address management of fisheries can be useful by helping to understand how much the yields and effort change or how efficient fishing had become during certain times and comparing that to data involving the catches. If a population is being fished and it is apparent that no more fish are being caught during times of vast technological improvement such as around 1880 or from 1947-1960, we can assume that the population is not holding steading, but is actually declining. Fishing is getting more efficient during that time so if the stocks were holding their populations, they would show an increase in catches.

If during the times of increased rate of development the catches are decreasing, we can assume that the populations are declining. This would indicate what happened to populations historically, but if we take this information into context now it can indicate when drastic management practices need to be taken to protect a species or population. On the contrary, increased catches during times of increased developments would indicate that a species is doing well and management has been more successful.

During times of less technological development there are clues that we can put together as well. If fish catches are holding steady during these times we can assume that the population is also holding steady. If there are no new technologies and fish catches are declining, we can assume that the population is also declining.

This data can be used for specific populations to understand their development and the effect of emerging technologies over time. If we can understand what historical populations looked like, management can be geared towards restoration of the species and aim for those population characteristics. It can also provide insights into the future of fisheries and populations. As more and more technologies are developed to make fishing increasingly efficient catch rates can tell us a story beyond just what fish are removed from the ocean. We can learn the warning signs for protecting future stocks and populations.

4.3 Further Research

I feel the next questions that can be asked of this research would delve into the multilingual portion of Google Books. While England, North America, and Australia were large contributors to my research, there is a whole world of other languages I was not able to search through Google Books. Even though I selected English, there were many Icelandic texts that came up. This piqued my interest not only about the possibility of Scandinavian texts, but also Asian and African. The English language seems like a good place to start, but by no means the end of this journey. Looking at Spanish and Portuguese would also open up the very fruitful waters of South America which have been exploited by other countries in the not-so-distant past, and would offer insight into a different facet of history. Many of the English books had a very biased view of other cultures and therefor this research begs to know the view from another side.

While fishing efforts and impacts have been noted by many different studies, there are few that allow the researcher to travel back to 1800, before the introduction of industrial fishing. For that reason, I truly think that this research is a fountain of information that should be fully utilized. Allowing for a view of all of industrial

fishing, instead of just the past 50 or 70 years, invites questions about changes over time since the beginning. When we can view a phenomenon or movement as a whole, it gives more insight into its development including positive and negative impacts on society, culture, and the lives of individual people.

5 Conclusion

Industrial fishing began in the 1880s with the introduction of the steam trawler. Since then there have been vast improvements in the technologies surrounding fisheries. These technologies have had a huge impact on different areas related to fisheries; some have impacted catch handling and storage, fish finding, fishing gear and operation, gear handling and operation, hulls and propulsion, navigation and communication, vessel types, and working conditions and safety.

Development in these technologies has not been steady. It has increased at various rates due to different events happening around the world. Social, cultural, and economic impacts are reflected in the rate of development of technologies in fisheries. World events have influenced the individual rate of development in all of these different categories.

This research has offered a view through the whole of industrial fishing of the rates of increases of technologies through the 208 different technologies introduced in the past 220 years. Peaks during 1880 and around 1947-1960 were recorded. These correlate with the introduction of industrial fishing and the industrialization of food post WWII.

These results provide insight into the different rates of development of fisheries over time. This method allows for a complete look at the whole length of industrial fishing, allows the development of a baseline before the introduction of industrial fishing, and can provide value to any study that looks to explain the introduction of technologies in fisheries or the rate of development of fisheries over time.

Bibliography

Anticamara, J. A., Watson, R., Gelchu, A., & Pauly, D. (2011). Global Fishing Effort (1950-2010): Trends, gaps, and implications. *Fisheries Research, 107*, 131-136.

Damalas, D., Maravelias, C. D., & Kavadas, S. (2014). Advances in Fishing Power: A study spanning 50 years. *Reviews in Fisheries Science & Aquaculture, 22*(1), 112-121.

Du, R. Y., Netzer, O., Schweidel, D. A., & Mitra, D. (2021). Capturing Marketing Information to Fuel Growth. *Journal of Marketing, 85*(1), 163-183.

Eigaard, O. R., Marchal, P., Gislason, H., & Rijnsdorp, A. D. (2014). Technological Development and Fisheries Management. *Reviews in Fisheries Science & Aquaculture, 22*(2), 156-174.

Engelhard, G. H. (n.d.). *One Hundred and Twenty Years of Change in Fishing Power of English North Sea Trawlers.*

FAO. (2020). *The State of World Fisheries and Aquaculture 2020.* Rome: FAO.

Farmer, J. D., & Lafond, F. (2016). How predictable is technological progress? *Research Policy, 45*(3), 647-665.

FAO, IFAD, UNICEF, WFP, WHO. (2018). *The State of Food Security and Nutrition: Building Climate Resilience for Food Security and Nutrition.*

Gabriel, O., Lange, K., Dahm, E., & Wendt, T. (2005). *Von Brandt's Fish Catching Methods of the World.* Oxford: Blackwell.

Geroski, P., & Vlassopoulos, T. (1991). The rise and fall of a market leader: Frozen foods in the U.K. *Strategic Management Journal, 12*(6), 467-478.

Greer, K., Zeller, D., Woroniak, J., Coulter, A., Winchester, M., Deng Palomares, M. L., & Pauly, D. (2019). Global Trends in Carbon Dioxide (CO2) Emissions from Fuel Combustion in Marine Fisheries from 1950-2016. *Marine Policy, 107*.

Hicks, C. C., Cohen, P. J., Graham, N. A., Nash, K. L., Allison, E. H., D'Lima, C., . . . MacNeil, M. A. (2019). Harnessing Global Fisheries to Tackle Micronutrient Deficiencies. *Nature, 574*, 95-98.

Hu, Z., Yang, Z., Li, Q., & Zhang, A. (2020). The COVID-19 infodemic: Infodemiology study analyzing stigmatizing search terms. *Journal of Medical Internet Research, 22*(11), e22639.

Jackson, R. J., Minjares, R., Naumoff, K. S., Shrimali, B. P., & Martin, L. K. (2009). Agriculture Policy is Health Policy. *Journal of Hunger & Environmental Nutrition, 4*(3), 393-408.

Kroodsma, D. A., Mayorga, J., Hochberg, T., Miller, N. A., Boerder, K., Ferretti, F., . . . Worm, B. (2018). Tracking the Global Footprint of Fisheries. *Science, 359*(6378), 904-908.

Kulkarni, A. A., Swinburn, B. A., & Utter, J. (2015). Associations Between Diet Quality and Mental Health in Socially Disadvantaged New Zealand Adolescents. *European Journal of Clinical Nutrition, 69*, 79-83.

Marmot, M., & Wilkinson, R. (2005). *Social Determinants of Health.* Oxford: University Press.

Merriam-Webster. (2021). *Baseline*. Retrieved January 2021, from Merriam-Webster.com: https://www.merriam-webster.com/dictionary/baseline

Merriam-Webster. (2021). *Demersal*. Retrieved January 2021, from Merriam-Webster.com: https://www.Merriam-Webster.com/dictionary/demersal

Merriam-Webster. (2021). *Effort*. Retrieved January 2021, from Merriam-Webster.com: https://www.merriam-webster.com/dictionary/effort

Merriam-Webster. (2021). *Fisheries*. Retrieved January 2021, from Merriam-Webster.com: https://www.merriam-webster.com/dictionary/fisheries

Merriam-Webster. (2021). *Technology*. Retrieved January 2021, from Merriam-Webster.com: https://www.merriam-webster.com/dictionary/technology

Michel, J.-B., Shen, Y. K., Aiden, A. P., Veres, A., Gray, M. K., The Google Books Team, . . . Aiden, E. L. (2011). Quantitative Analysis of Culture Using Millions of Digitized Books. *Science, 331*(6014), 176-182.

Nesheim, M. C., Oria, M., & Tsai Yih, P. (2015). *Framework for assessing effects of the food system.* National Academies Press.

Paterson, B. D., Grauf, S. G., & Smith, R. A. (1997). Haemolymph chemistry of tropical rock lobersters (Panulirus ornatus) brought onto a mother ship from a catching dinghy in Torres Strait`. *Mar. Freshwater Res., 48*, 835-838.

Pauly, D., & Zeller, D. (2016). Catch Reconstructions Reveal That Global Marine Fisheries Catches are Higher than Reported and Declining . *Nature Communications*.

Robins, C. M., Wang, Y.-G., & Die, D. (1998). The Impact of Global Positioning Systems and Plotters on Fishing Power in the Northern Prawn Fishery, Australia. *Can. J. Fish. Auat. Sci., 55*, 1645-1651.

Rousseau, Y., Watson, R. A., Blanchard, J. L., & Fulton, E. A. (2019). Evolution of Global Marine Fishing Fleets and the Response of Fished Resources. *PNAS, 116*(25), 12238-12243.

Shiga, J. (2013). Sonar: Empire, media, and the politics of underwater sound. *Canadian Journal of Communication, 38*(3), 357-377.

Sumaila, U. R., Lam, V., Le Manach, F., Swartz, W., & Pauly, D. (2016). Global fisheries subsidies: An updated estimate. *Marine Policy, 69*, 189-193.

Sun, K., & Baayen, R. H. (2021). Hyphenation as a compounding technique in English. *Language Sciences, 83*, 101326.

Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., & Rihan, D. (2012). Low impact and fuel efficient fishing - Looking beyond the horizon. *Fisheries Research, 119-120*, 135-146.

Swartz, W., & Ishimura, G. (2014). Baseline assessment of total fisheries-related biomass removal from Japan's Exclusive Economic Zones: 1950-2010. *Fish Sci, 80*, 643-651.

Teitelbaum, M. S. (2020). *The developing countries since 1950*. Retrieved January 2021, from Britannica: https://www.britannica.com/science/population-biology-and-anthropology/The-developing-countries-since-1950

Wilcox, M. (2012). Railways, roads and the British white fish industry 1920-70. *Business History, 54*(5), 741-764.

Appendix 1: Timeline of Introduction of Technology

Category	Technology Name	Date	Location of use	Publication	Type of Publication
Catch handling and storage	Hold	1800		Denmark	Book
Fishing gear and operation (in-water)	Trolling	1800		London	Dictionary/Encyclopedia
Gear handling and operation	Winch	1800		London	Dictionary/Encyclopedia
Navigation and Communication	Compass	1801	Canada	London	Book
Fishing gear and operation (in-water)	Dredge	1803		London	Dictionary/Encyclopedia
Fishing gear and operation (in-water)	Trawl	1803		London	Dictionary/Encyclopedia
Fishing gear and operation (in-water)	Seine net	1805	USA	Dover	Government Publication
Gear handling and operation	Capstan	1809		London	Dictionary/Encyclopedia
Fishing gear and operation (in-water)	Ring net	1809		Edinburgh	Government Publication
Fishing gear and operation (in-water)	Drift net	1812	USA	Philadelphia	Government Publication
Fishing gear and operation (in-water)	Gut line	1814	UK	London	Book
Navigation and Communication	Map	1815	British Empire	London	Book
Fishing gear and operation (in-water)	Light fishing	1819	Lake Ontario	London	Book
Navigation and Communication	Sextant	1819	Egypt	Glasgow	Book
Fishing gear and operation (in-water)	Jigging	1825		London	Magazine/Journal
Fishing gear and operation (in-water)	Trammel net	1832	British Isles	USA	Government Publication
Gear handling and operation	Flagstaff	1832	China	London	Magazine/Journal
Fishing gear and operation (in-water)	Lure	1835		London	Magazine/Journal

Fishing gear and operation (in-water)	Spears and harpoons	1839	Mediterranean	London	Dictionary/Encyclopedia
Fishing gear and operation (in-water)	Beam trawl	1841		London	Magazine/Journal
Working conditions and safety	Flare	1843	Maine	Boston	Book
Hulls and propulsion	Wheelhouse	1851		Philadelphia	Magazine/Journal
Fishing gear and operation (in-water)	Trawl twine	1853		Dublin	Book
Hulls and propulsion	Bilge pump	1854	North American Atlantic	Washington D.C.	Government Publication
Working conditions and safety	Life boat	1857			Magazine/Journal
Working conditions and safety	Rubber boots	1859	USA	New York	Book
Catch handling and storage	Skinning machine	1860		USA	Magazine/Journal
Fishing gear and operation (in-water)	Cotton net	1861		London	Book
Fishing gear and operation (in-water)	Longline	1861		Glasgow	Magazine/Journal
Gear handling and operation	Pulley block	1863		London	Magazine/Journal
Navigation and Communication	Steering wheel	1864	Norway	New York	Magazine/Journal
Fishing gear and operation (in-water)	Otter trawl	1865		Guernsey	Book
Hulls and propulsion	Single hull	1865	Polynesia	London	Book
Fishing gear and operation (in-water)	Steel rod	1867		London	Government Publication
Hulls and propulsion	Screw propeller	1867		London	Government Publication
Navigation and Communication	Telegraphy	1869		New York	Magazine/Journal
Navigation and Communication	Binnacle	1871	Cornwall	London	Book

Catch handling and storage	Weighing scale	1871	New York	USA	Magazine/Journal
Catch handling and storage	Vacuum system	1871	Australia & UK		Magazine/Journal
Working conditions and safety	Souwester	1872		St. John, NB	Magazine
Hulls and propulsion	Propeller	1872		Philadelphia	Magazine/Journal
Fishing gear and operation (in-water)	Bobbin	1875		London	Magazine/Journal
Catch handling and storage	Ice crusher	1876		USA	Government Publication
Hulls and propulsion	Steam power	1877		Washington D.C.	Government Publication
Gear handling and operation	Steam capstan	1877		London	Magazine/Journal
Hulls and propulsion	Electric power	1877		USA	Magazine/Journal
Catch handling and storage	Ice machine	1878		USA	Government Publication
Catch handling and storage	Autoclave	1879		Melbourne	Government Publication
Gear handling and operation	Trawl winch	1879		Washington DC	Government Publication
Vessel types	Steam trawler	1879	Buckhaven	London	Government Publication
Fishing gear and operation (in-water)	Manila line	1879		New York	Magazine/Journal
Fishing gear and operation (in-water)	Purse seine	1880		New York	Book
Gear handling and operation	Baiting machine	1880	Great Britain	London	Book
Catch handling and storage	Refridgeration	1880		USA	Government Publication
Fishing gear and operation (in-water)	Manila rope	1880		Washington DC	Government Publication
Fishing gear and operation (in-water)	Circle hook	1881	Tibet	London	Book

Gear handling and operation	Bullseye	1881		New York	Magazine/Journal
Gear handling and operation	Net hauler	1883		London	Government Publication
Working conditions and safety	Life jacket	1883		London	Government Publication
Fishing gear and operation (in-water)	Bottom trawl	1883		New York	Magazine/Journal
Fishing gear and operation (in-water)	Manilla Net	1883		London	Newspaper
Hulls and propulsion	Power steering	1884		London	Government Publication
Fishing gear and operation (in-water)	Swivel line	1886		London	Magazine/Journal
Fish finding	Sounding line	1887		Washington DC	Government Publication
Gear handling and operation	Binder twine	1887		Melbourne	Government Publication
Catch handling and storage	Glazing machine	1887		USA	Magazine/Journal
Hulls and propulsion	Paddle steam	1889	Great Britain	Washington D.C.	Book
Catch handling and storage	Scaling machine	1891		New York	Dictionary/Encyclopedia
Catch handling and storage	Sorting machine	1899		London	Book
Gear handling and operation	Mast truck	1899		Boston	Book
Fishing gear and operation (in-water)	Braid line	1899	Montreal	Toronto	Magazine/Journal
Hulls and propulsion	Pitch propeller	1899		London	Magazine/Journal
Fishing gear and operation (in-water)	Danish seine	1900	Norway	Kristiania	Book
Hulls and propulsion	Four bladed propeller	1900		Boston	Government Publication
Gear handling and operation	Fish pump	1900	France	New York	Magazine/Journal

Gear handling and operation	Net winch	1901		Washington DC	Government Publication
Gear handling and operation	Telemeter	1901		Washington DC	Government Publication
Hulls and propulsion	Ballast pump	1901		Leith	Magazine/Journal
Hulls and propulsion	Marine engine	1904	Alaska	Cincinnati	Magazine/Journal
Hulls and propulsion	Three-bladed propeller	1905		London & New York	Book
Catch handling and storage	Gutting machine	1905		Glasgow	Government Publication
Hulls and propulsion	Petrol power	1905		New York	Magazine/Journal
Catch handling and storage	Fish grinder	1908	Washington State	USA	Government Publication
Fishing gear and operation (in-water)	Pelagic trawl	1911		New York & London	Magazine/Journal
Gear handling and operation	Line hauler	1912		New York	Book
Fishing gear and operation (in-water)	Lampara net	1913	California	California	Government Publication
Gear handling and operation	Trawl door	1915		Rhode Island	Government Publication
Navigation and Communication	Direction finder	1915		Washington D.C.	Government Publication
Gear handling and operation	Seine winch	1915		Seattle	Magazine/Journal
Hulls and propulsion	Inboard motor	1915	California	Seattle	Magazine/Journal
Working conditions and safety	Rescue boat	1916	Guatamala	Chicago	Book
Hulls and propulsion	Diesel power	1916	US Pacific Coast	Seattle	Magazine/Journal

Catch handling and storage	Conveyor belt	1921		USA	Magazine/Journal
Hulls and propulsion	Crude oil power	1921	New England	Cleveland	Magazine/Journal
Navigation and Communication	Tachometer	1921		new York	Magazine/Journal
Vessel types	Motor trawler	1921	Gulf of Mexico	USA	Magazine/Journal
Vessel types	Diesel electric trawler	1921		New York	Magazine/Journal
Catch handling and storage	Fishmeal plant	1922	California	Seattle	Magazine/Journal
Catch handling and storage	Fishmeal machine	1923	California	USA	Government Publication
Working conditions and safety	Sheltered deck	1930	Alaska	Washington DC	Government Publication
Navigation and Communication	Radio telephone	1936	Boston	New York	Corporate Report
Hulls and propulsion	Outboard motor	1937	Massachusets	USA	Government Publication
Catch handling and storage	Nobbing machine	1946		USA	Government Publication
Catch handling and storage	Filleting machine	1947		Canada	Government Publication
Vessel types	Mothership	1947	Pacific	Washington D.C.	Government Publication
Catch handling and storage	Sorting belt	1948		Washington DC	Government Publication
Catch handling and storage	Peeling machine	1949	Australia	London	Government Publication
Catch handling and storage	Blast freezer	1949		London	Government Publication
Gear handling and operation	Dredge winch	1949		USA	Government Publication
Gear handling and operation	Trawl float	1950		Washington DC	Government Publication
Navigation and Communication	Radar	1950	Los Angeles	USA	Magazine/Journal

Catch handling and storage	Shrimp grader	1951	Sydney	Washington DC	Government Publication
Catch handling and storage	Breading line	1952		USA	Government Publication
Fish finding	Ultrasonic transducer	1952		Washington DC	Government Publication
Gear handling and operation	Deck crane	1952	Oregon and Washington	USA	Government Publication
Fishing gear and operation (in-water)	Synthetic bait	1953	USA	USA	Government Publication
Gear handling and operation	Trawl drum	1953		USA	Government Publication
Fish finding	ASDIC	1954		Washington DC	Government Publication
Working conditions and safety	Radar reflector	1955		Washington D.C.	Government Publication
Catch handling and storage	Battering machine	1956		USA	Government Publication
Fishing gear and operation (in-water)	Monofilament line	1956		USA	Magazine/Journal
Catch handling and storage	Filleting line	1957	Oregon	Washington	Government Publication
Fishing gear and operation (in-water)	Midwater trawl	1957	Washington State	Washington DC	Government Publication
Hulls and propulsion	Kort nozzle	1957		Washington DC	Government Publication
Navigation and Communication	LORAN	1957	Florida	USA	Government Publication
Catch handling and storage	Smoking machine	1958		USA	Government Publication
Catch handling and storage	Shrimp cooker	1958		Washington DC	Government Publication

Catch handling and storage	Tunnel freezer	1958	USSR	Washington DC	Government Publication
Fishing gear and operation (in-water)	Synthetic fiber	1958		Washington DC	Government Publication
Fishing gear and operation (in-water)	Polyester fiber	1958		Washington DC	Government Publication
Gear handling and operation	Tension meter	1958		Washington D.C.	Government Publication
Catch handling and storage	Fish grading system	1960		Washington DC	Government Publication
Vessel types	Super trawler	1960	Germany	USA	Government Publication
Gear handling and operation	Power block	1960		USA	Magazine/Journal
Fishing gear and operation (in-water)	Scottish seine	1961		Washington DC	Government Publication
Navigation and Communication	Satellite telephone	1962	Western Pacific	Washington D.C.	Government Publication
Hulls and propulsion	Glass fibre	1962		London	Magazine/Journal
Catch handling and storage	Breading machine	1963	Iceland	California	Book
Fishing gear and operation (in-water)	Automatic jigger	1963		USA	Government Publication
Fishing gear and operation (in-water)	Nylon net	1963	California	USA	Government Publication
Fishing gear and operation (in-water)	Monofilament net	1963	Hawaii	USA	Government Publication
Hulls and propulsion	Thruster	1963		USA	Government Publication

Hulls and propulsion	Twostroke	1963		Washington D.C.	Government Publication
Hulls and propulsion	Fourstroke	1963		Washington D.C.	Government Publication
Navigation and Communication	Chart recorder	1963		USA	Government Publication
Vessel types	Stern trawler	1963		UsA	Government Publication
Catch handling and storage	Heading machine	1964		Washington DC	Government Publication
Gear handling and operation	Trawl camera	1964		Washington DC	Government Publication
Hulls and propulsion	Gearbox	1964		Washington D.C.	Government Publication
Vessel types	Side trawler	1964		USA	Government Publication
Hulls and propulsion	Fuel meter	1965		Washington D.C.	Government Publication
Navigation and Communication	Omega receiver	1968		USA	Magazine/Journal
Gear handling and operation	Pot hauler	1970		USA	Government Publication
Catch handling and storage	Fish grader	1971	California	USA	Government Publication
Fish finding	Multibeam	1971		USA	Government Publication
Gear handling and operation	Net drum	1972		USA	Government Publication
Fishing gear and operation (in-water)	Non returnable funnel	1973	Singapore	Singapore	Book
Catch handling and storage	Deboner	1973		Virginia	Government Publication
Catch handling and storage	Bone separator	1973		USA	Government Publication
Fish finding	Sonar	1973		Michigan	Government Publication

Fishing gear and operation (in-water)	Gillnet	1973	N America	Ottawa	Government Publication
Fishing gear and operation (in-water)	Soft plastic bait	1973		New York	Magazine/Journal
Catch handling and storage	Strapping machine	1977		USA	Government Publication
Catch handling and storage	Eviscerating machine	1977		USA	Government Publication
Navigation and Communication	Variable range marker	1977		San Francisco	Government Publication
Navigation and Communication	Facsimile receiver	1978	Indonesia	San Francisco	Government Publication
Navigation and Communication	Autopilot	1978		New York	Magazine/Journal
Gear handling and operation	Net monitor	1979		USA	Government Publication
Gear handling and operation	Autotrawl	1979		Washington D.C.	Government Publication
Navigation and Communication	VHF	1979	Florida	USA	Magazine/Journal
Catch handling and storage	RSW tank	1980		USA	Government Publication
Fishing gear and operation (in-water)	Speargun	1980		USA	Government Publication
Fish finding	Video sounder	1982		USA	Magazine/Journal
Catch handling and storage	Trimming line	1984	Washington and Oregon	USA	Government Publication
Fish finding	Colorscope	1985		USA	Government Publication
Navigation and Communication	Mobile phone	1986	Canada	USA	Magazine/Journal
Catch handling and storage	Grading machine	1988		Rome (FAO)	FAO
Fishing gear and operation (in-water)	Turtle excluder device	1988		USA	Government Publication

Hulls and propulsion	Multi hull	1988		Washington DC	Government Publication
Working conditions and safety	Survival suit	1991	Alaska	New York	Book
Navigation and Communication	Dynamic positioning	1993		Cambridge	Book
Fishing gear and operation (in-water)	Longline float	1993		USA	Government Publication
Gear handling and operation	Net sounder	1993		USA	Government Publication
Gear handling and operation	Catch sensor	1993		Copenhagen	Government Publication
Navigation and Communication	Inmarsat	1993		Copenhagen	Government Publication
Fishing gear and operation (in-water)	Glass fibre rod	1994		London	Book
Fishing gear and operation (in-water)	Rockhopper	1997			Book
Fishing gear and operation (in-water)	Carbon fibre rod	1998		Great Britain	Book
Fishing gear and operation (in-water)	Longline snap	1998		USA	Government Publication
Navigation and Communication	Automatic Identification System	2001		UK (IUCN)	Book
Hulls and propulsion	Wheelhouse chair	2001	UK	USA	Government Publication
Navigation and Communication	Global positioning system	2001	USA	USA	Government Publication
Catch handling and storage	Flake ice maker	2003		Rome (FAO)	FAO
Catch handling and storage	Weight computer	2004		USA	Book
Gear handling and operation	Rope drum	2004	Australia	New York	Book
Gear handling and operation	Trawl sonar	2004		USA	Book
Catch handling and storage	Plate freezer	2005		Philippines	Book

Fish finding	Echo sounder	2005		Oxford	Book
Gear handling and operation	Net stacker	2005		London	Book
Fishing gear and operation (in-water)	Long line clip	2005		USA	Government Publication
Catch handling and storage	Glazing line	2006		Iowa	Book
Catch handling and storage	Gutting line	2008		Cambridge	Book
Fishing gear and operation (in-water)	Alvey reel	2008	New Zealand	New Zealand	Book
Catch handling and storage	Can seamer	2009		USA	Dictionary/Encyclopedia
Fish finding	Colour sounder	2010	Australia	Australia	Book
Fish finding	Colour sonar	2011		Delhi	Book
Catch handling and storage	Roller grader	2016		UAE	Book
Fishing gear and operation (in-water)	Pulse trawl	2016		Oxford	Book

Appendix 2: Popular Scientific Review

Fisheries are an important part of the global food system. They provide crucial nutrition and financially support almost 60 million people. Proper management is key to ensuring that this resource is used sustainably as global fisheries develop and change. Understanding how fisheries develop and change can give insight into the history of fisheries and the health of populations and stocks. One way to understand those changes is to look at the development of industrial fishing over time.

Industrial fishing started around 1880 with the invention of the steam trawler. It increased the efficiency of fishing by allowed for more fish to be caught at a quicker pace. With the introduction of these new technologies the face of fishing changed forever.

Most research looks back to around the middle of the 20th century. This is when some records began and accounts became more reliable. Using more reliable accounts allows for a more in-depth look at fisheries. These records however do not account for the first decades of industrial fishing. There are about 70 years unaccounted for in these records. Finding a way to look at the complete record of industrial fishing and the technological development through that time is key to understanding the full impact of industrial fishing on fishing stocks and give insight into management.

Google books is a large collection of published works from 1800 to present. It is made up of scanned documents from multiple libraries in addition to the Google books team. Using Google books to look for documents that are the first recorded use of certain technologies can result in a timeline of technology development in fisheries. This information can be used to understand the rates of development over time and the increases in efficiency.

A list of 208 words were gathered from a professional conference and inserted into Google books to find documents mentioning their use in fisheries. The timeline was then made into graphs depicting the changing rate over time and the different categories and their development.

The most important findings were that there were two spikes of technology introduction in the timeline. One was around 1880 with the introduction of industrial fishing and the second was from 1947-1960 which was after World War II and correlates to another change in the food system. With a growing population and increased food preservation technologies, post-World War II food systems relied more on mechanization, large-scale output, and making highly processed foods.

Also of importance was that most of the recorded first uses were in government publications followed by trade magazines and journals. This seems to indicate a

governmental influence over the new technologies and their introductions to industrial fishing systems.

This information can be used in management decisions by helping to understand the changes in populations and efficiency. As more technologies are added at an increasing rate the efficiency will also increase. If we see that catch numbers are holding steady during these peaks, we can assume that populations are actually decreasing since the efficiency of that catch is increasing. Following this logic if catch numbers decrease then populations are more steeply decreasing and if catches increase populations are either holding steady of increasing.

There are some limitations to this work such as a limited database of publications and only focusing on documents in English, however both of these could be mitigated by further research. Further research could help increase the scope of the terms and add more detail to the results and understandings gained.

As of now these results have the potential to be a key piece of information to help understand the changes over time of an important part of the food system that provides sustenance and income to many. It is an important natural resource that needs to be nurtured and better understood to ensure its sustainability in the distant, or near, future.

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file. If you are more than one author, the checked box will be applied to all authors. You will find a link to SLU's publishing agreement here:

- https://libanswers.slu.se/en/faq/228318.

☒ YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

☐ NO, I/we do not give permission to publish the present work. The work will still be archived and its metadata and abstract will be visible and searchable.